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(54) **METAL OXIDE VARISTOR WITH REINFORCED ELECTRODES**

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**H01C 1/14** (2006.01)  
**H01C 7/108** (2006.01)

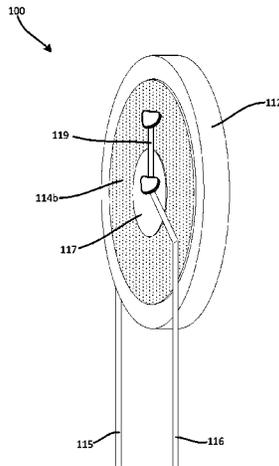
(57) **ABSTRACT**

(52) **U.S. Cl.**  
CPC ..... **H01C 7/126** (2013.01); **H01C 1/14** (2013.01); **H01C 7/108** (2013.01)

A metal oxide varistor (MOV) device including a MOV chip, electrically conductive first and second electrodes disposed on opposite sides of the MOV chip, and electrically conductive first and second leads connected to the first and second electrodes, respectively, wherein the first and second electrodes are formed of a material having a melting point greater than 1100 degrees Celsius.

(58) **Field of Classification Search**  
CPC ..... H01C 7/126; H01C 1/14; H01C 7/108  
See application file for complete search history.

**15 Claims, 2 Drawing Sheets**



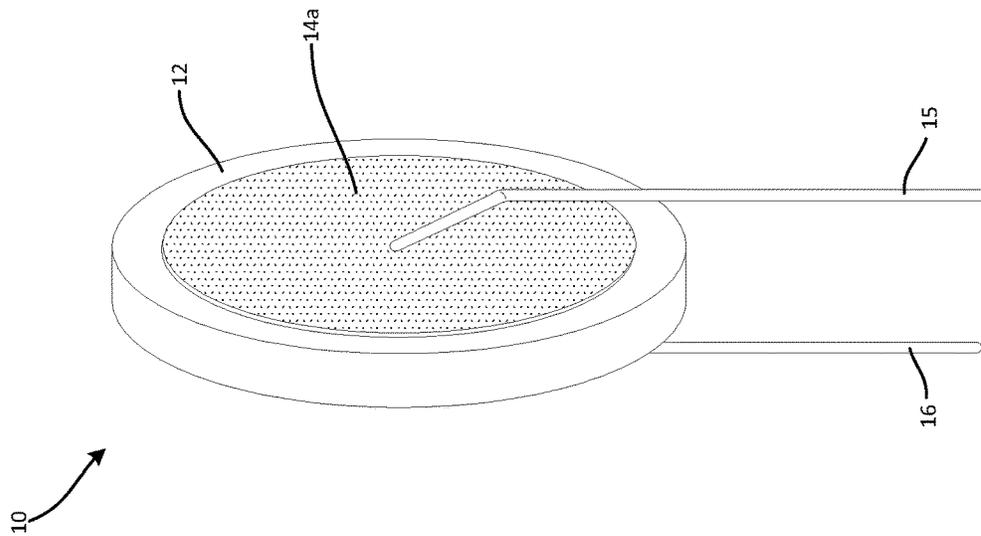
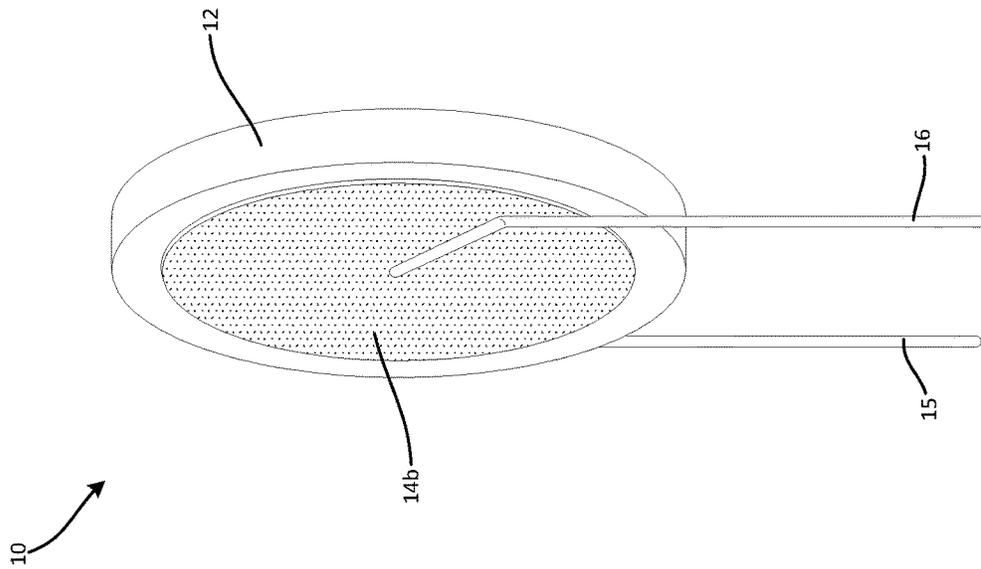
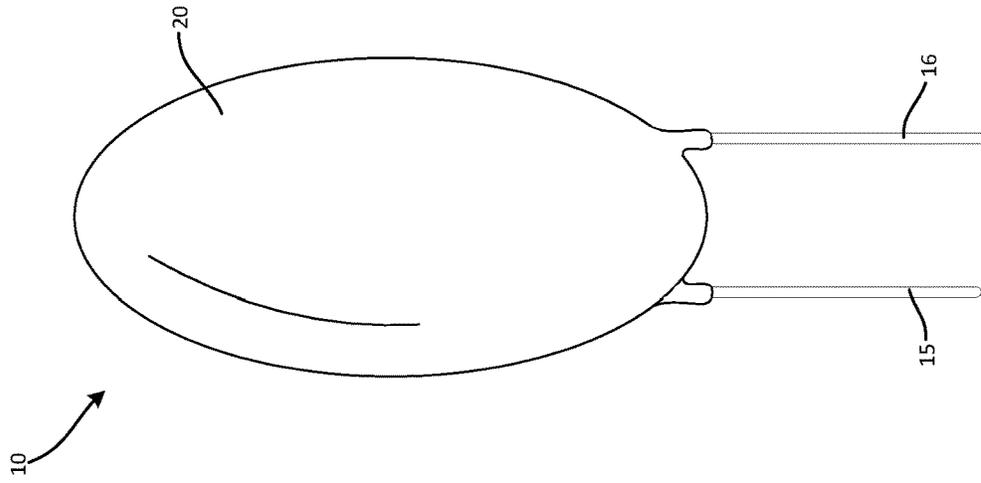


Fig. 1C

Fig. 1B

Fig. 1A

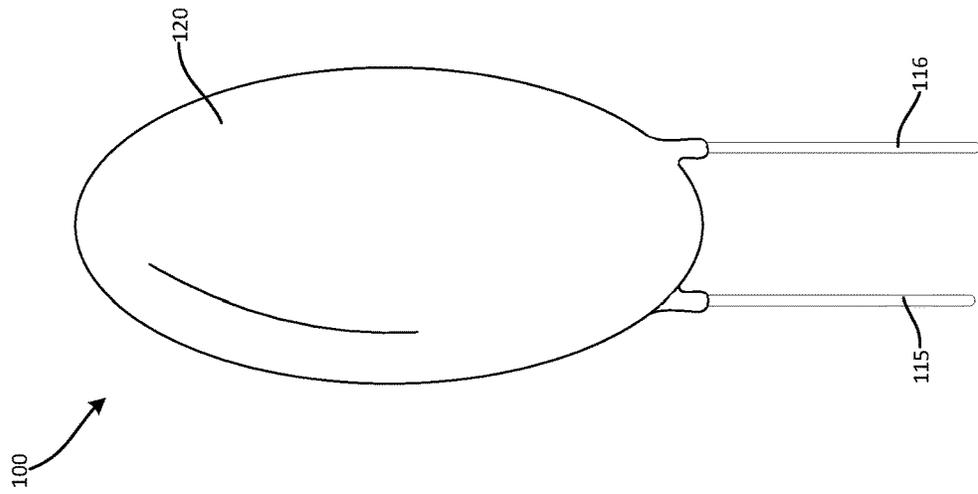


Fig. 2C

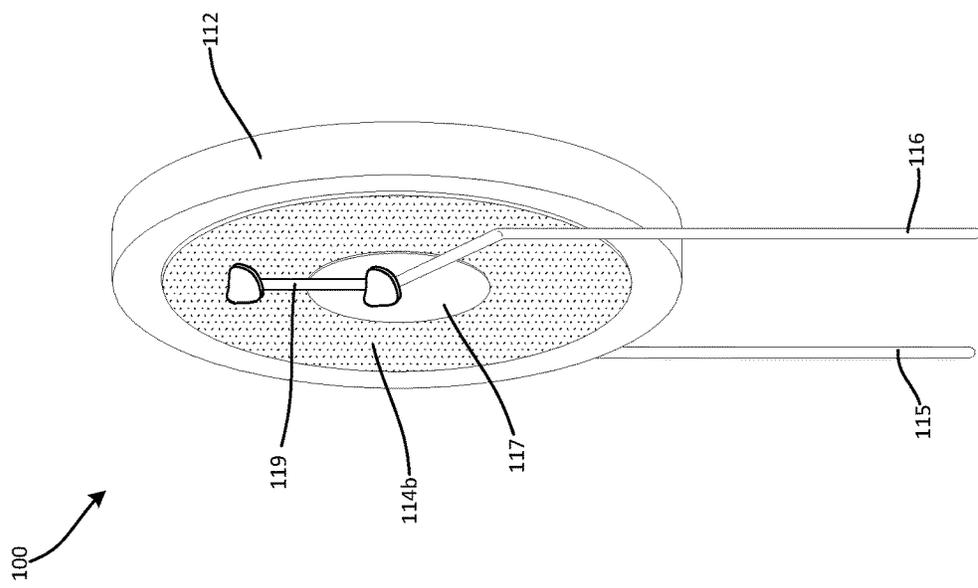


Fig. 2B

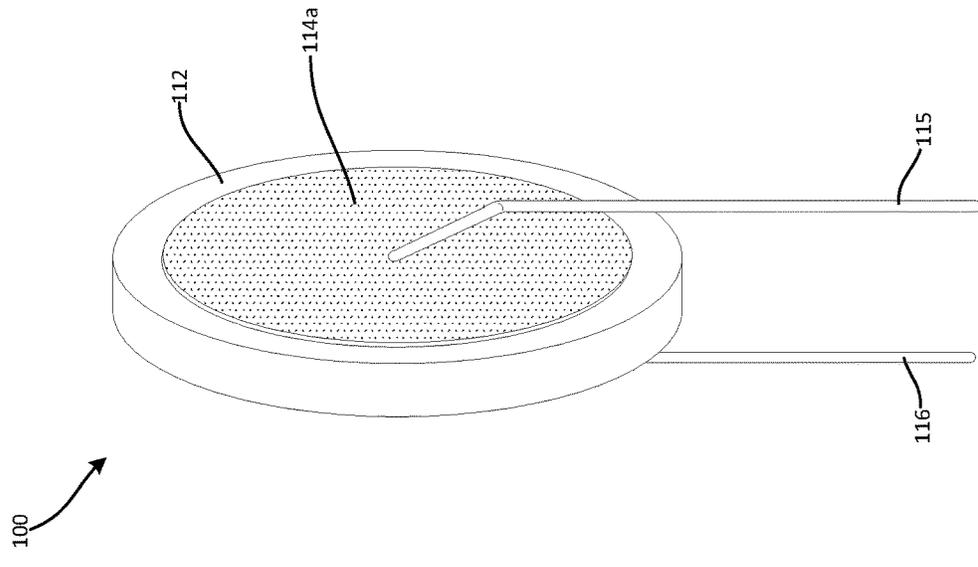


Fig. 2A

## METAL OXIDE VARISTOR WITH REINFORCED ELECTRODES

### BACKGROUND

#### Field

The present disclosure relates generally to the field of circuit protection devices. More specifically, the present disclosure relates to a metal oxide varistor that is resistant to combustion when subjected to excessive heating.

#### Description of Related Art

Metal oxide varistors (MOVs) are voltage dependent, nonlinear devices that provide transient voltage suppression in electronic circuits. A MOV has high electrical resistance when subjected to a low voltage and a low electrical resistance when subjected to a high voltage. When connected in parallel with a protected circuit component, a MOV can clamp voltage to a safe level in the event of a high transient voltage in the circuit. The MOV thus absorbs energy that could otherwise damage the protected component.

A shortcoming associated with traditional MOVs is that they are prone to electrical punch through when subjected to high local current, which can lead to excessive heating and subsequent combustion. For example, in the event of an abnormal overvoltage condition, a MOV may overheat and may experience thermal runaway and/or electrical puncture, whereby hot plumes of gas can rupture electrodes on the exterior surfaces of the MOV and melt or ignite the polymer outer coating of the MOV.

It is with respect to these and other considerations that the present improvements may be useful.

### SUMMARY

This Summary is provided to introduce a selection of concepts in a simplified form further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is the summary intended as an aid in determining the scope of the claimed subject matter.

A metal oxide varistor (MOV) device in accordance with an exemplary embodiment of the present disclosure may include a MOV chip, electrically conductive first and second electrodes disposed on opposite sides of the MOV chip, and electrically conductive first and second leads connected to the first and second electrodes, respectively, wherein the first and second electrodes are formed of a material having a melting point greater than 1100 degrees Celsius.

A thermally protected metal oxide varistor (TMOV) device in accordance with an exemplary embodiment of the present disclosure may include a MOV chip, electrically conductive first and second electrodes disposed on opposite sides of the MOV chip, an electrically conductive first lead connected to the first electrode, an electrically conductive second lead connected to a dielectric barrier disposed on the second electrode, and a thermal cutoff (TCO) element having a first end electrically connected to the second lead on the dielectric barrier and a second end electrically connected to the second electrode, wherein the first and second electrodes are formed of a material having a melting point greater than 1100 degrees Celsius.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a front perspective view illustrating a MOV device in accordance with an exemplary embodiment of the present disclosure;

FIG. 1B is a rear perspective view illustrating the MOV device of FIG. 1A;

FIG. 1C is a rear perspective view illustrating the MOV device of FIG. 1A with a polymer coating;

FIG. 2A is a front perspective view illustrating a TMOV device in accordance with an exemplary embodiment of the present disclosure;

FIG. 2B is a rear perspective view illustrating the TMOV device of FIG. 2A;

FIG. 2C is a rear perspective view illustrating the TMOV device of FIG. 2A with a polymer coating.

### DETAILED DESCRIPTION

Exemplary embodiments of metal oxide varistors (MOVs) having reinforced electrodes in accordance with the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings. The MOVs may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will convey certain exemplary aspects of the MOVs to those skilled in the art.

Referring to FIGS. 1A and 1B, front and rear views of an exemplary embodiment of a MOV device **10** in accordance with the present disclosure are shown. The MOV device **10** may include a MOV chip **12** having first and second electrically conductive electrodes **14a**, **14b** disposed on opposite sides thereof. The MOV chip **12** may be formed of any MOV composition known in the art, such as multi crystalline zinc oxide ceramic. The present disclosure is not limited in this regard.

The MOV chip **12** and the electrodes **14a**, **14b** are depicted as being circular in shape, but this is not critical. It is contemplated that one or more of the MOV chip **12** and the electrodes **14a**, **14b** may have a different shape, such as rectangular, triangular, irregular, etc. without departing from the scope of the present disclosure.

The MOV device **10** may further include electrically conductive first and second leads **15**, **16** connected to the first and second electrodes **14a**, **14b**, respectively, for facilitating electrical connection of the MOV device **10** within a circuit. In various non-limiting embodiments, the first and second leads **15**, **16** may be electrically connected to the first and second electrodes **14a**, **14b** via soldering, welding, electrically conductive adhesive, etc.

Referring to FIG. 1C, the MOV device **10** may further include a dielectric polymer coating **20** that covers the MOV chip **12**, the first and second electrodes **14a**, **14b**, and portions of the first and second leads **15**, **16**. The polymer coating **20** may protect the components of the MOV device **10** from environmental elements and may prevent electrical shorting between the MOV device **10** and surrounding circuit components.

The first and second electrodes **14a**, **14b** of the MOV device **10** may be formed of an electrically conductive material that is more thermally resistant (e.g., has a higher melting point) than metals such as aluminum, copper, or silver that are traditionally used to form the electrodes of MOV devices. For example, the first and second electrodes **14a**, **14b** may be formed of various ferrous-based materials, including, but not limited to, galvanized steel, tin-coated

steel, or composite materials such as cermet (a composite of metal and ceramic). In various non-limiting embodiments, the first and second electrodes **14a**, **14b** may be formed of a material having a melting point greater than 1100 degrees Celsius. In various embodiments, the first and second electrodes **14a**, **14b** may have a thickness in a range of 0.2 to 0.6 millimeters. The present disclosure is not limited in this regard.

Owing to the enhanced durability and thermal resistance of the electrodes **14a**, **14b** relative to conventional MOV electrodes, the first and second electrodes **14a**, **14b** of the MOV device **10** may be highly resistant to rupturing that could otherwise result from thermal runaway and/or electrical puncture in the MOV chip **12** upon overheating. The risk of the polymer coating **20** of the MOV device **10** being ignited during an overheating event as thereby greatly mitigated relative to MOV devices having conventional electrodes.

Referring to FIGS. **2A** and **2B**, front and rear views of an exemplary embodiment of a thermally protected metal oxide varistor device **100** (hereinafter “the TMOV device **100**”) in accordance with the present disclosure are shown. The TMOV device **100** may include a MOV chip **112** having first and second electrically conductive electrodes **114a**, **114b** disposed on opposite sides thereof. The MOV chip **112** may be formed of any MOV composition known in the art, such as zinc oxide granules embedded in ceramic. The present disclosure is not limited in this regard.

The MOV chip **112** and the first and second electrodes **114a**, **114b** are depicted as being circular in shape, but this is not critical. It is contemplated that one or more of the MOV chip **112** and the first and second electrodes **114a**, **114b** may have a different shape, such as rectangular, triangular, irregular, etc. without departing from the scope of the present disclosure.

The TMOV device **100** may further include electrically conductive first and second leads **115**, **116** for facilitating electrical connection of the TMOV device **100** within a circuit. The first lead **115** may be connected directly to the first electrode **114a** on the front side of the MOV chip **112** via soldering, welding, electrically conductive adhesive, etc. The second lead **116** may be connected to a dielectric barrier **117** disposed on the rear side of the MOV chip **112** via soldering, adhesive, etc. The dielectric barrier **117** may be formed of ceramic or other dielectric material and may prevent direct electrical connection between the second lead **116** and the second electrode **114b**. The TMOV device **100** may further include a thermal cutoff (TCO) element **119** having a first end electrically connected to the second lead **116** on the dielectric barrier **117** (e.g., via soldering) and a second end electrically connected to the second electrode **114b** (e.g., via soldering). The TCO element **119** may be formed of an electrically conductive material and may be adapted to melt and separate upon reaching a predetermined temperature (e.g., 140 degrees Celsius-240 degrees Celsius). During normal operation, the TMOV device will operate in the manner of a normal MOV device. However, upon the occurrence of an overtemperature condition in the TMOV device **100**, the TCO element **119** will melt, thereby arresting current flowing through the TMOV device **100** and preventing further heating that could ignite the TMOV device **100** and damage surrounding components.

Referring to FIG. **2C**, the TMOV device **100** may further include a polymer coating **120** that covers the MOV chip **112**, the first and second electrodes **114a**, **114b**, the dielectric barrier **117**, the TCO element **119**, and portions of the first and second leads **115**, **116**. The polymer coating **120** may

protect the components of the TMOV device **100** from environmental elements and may prevent electrical shorting between the TMOV device **100** and surrounding circuit components.

As in the MOV device **10** described above, the first and second electrodes **114a**, **114b** of the TMOV device **100** may be formed of an electrically conductive material that is more thermally resistant (e.g., has a higher melting point) than metals such as aluminum, copper, or silver that are traditionally used to form the electrodes of TMOV devices. For example, the first and second electrodes **114a**, **114b** may be formed of various iron-based materials, including, but not limited to, galvanized steel, tin-coated steel, or composite materials such as cermet (a composite of metal and ceramic). In various non-limiting embodiments, the first and second electrodes **114a**, **114b** may have a thickness in a range of 0.2 to 0.6 millimeters. The present disclosure is not limited in this regard.

Owing to the enhanced durability and thermal resistance of the electrodes **114a**, **114b** relative to conventional TMOV electrodes, the first and second electrodes **114a**, **114b** of the TMOV device **100** may be highly resistant to rupturing that could otherwise result from thermal runaway and/or electrical puncture in the MOV chip **112** upon overheating. The risk of the polymer coating **120** of the TMOV device **110** being ignited during an overheating event as thereby greatly mitigated relative to TMOV devices having conventional electrodes.

As used herein, an element or step recited in the singular and proceeded with the word “a” or “an” should be understood as not excluding plural elements or steps, unless such exclusion is explicitly recited. Furthermore, references to “one embodiment” of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features.

While the present disclosure makes reference to certain embodiments, numerous modifications, alterations and changes to the described embodiments are possible without departing from the sphere and scope of the present disclosure, as defined in the appended claim(s). Accordingly, it is intended that the present disclosure not be limited to the described embodiments, but that it has the full scope defined by the language of the following claims, and equivalents thereof.

The invention claimed is:

1. A metal oxide varistor (MOV) device comprising:
  - a MOV chip;
  - electrically conductive first and second electrodes disposed on opposite sides of the MOV chip; and
  - electrically conductive first and second leads connected to the first and second electrodes, respectively;
 wherein the first and second electrodes are formed of a material having a melting point greater than 1100 degrees Celsius, and wherein the first and second electrodes are planar and are disposed in a parallel relationship with one another.
2. The MOV device of claim **1**, wherein the first and second electrodes are formed of a ferrous-based material.
3. The MOV device of claim **2**, wherein the first and second electrodes are formed of galvanized steel.
4. The MOV device of claim **2**, wherein the first and second electrodes are formed of tin-coated steel.
5. The MOV device of claim **2**, wherein the first and second electrodes are formed of cermet.

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6. The MOV device of claim 1, wherein the first and second electrodes have a thickness in a range of 0.2 to 0.6 millimeters.

7. The MOV device of claim 1, further comprising a dielectric polymer coating covering the MOV chip, the first and second electrodes, and portions of the first and second leads.

8. A thermally protected metal oxide varistor (TMOV) device comprising:

a MOV chip;

electrically conductive first and second electrodes disposed on opposite sides of the MOV chip;

an electrically conductive first lead connected to the first electrode;

an electrically conductive second lead connected to a dielectric barrier disposed on the second electrode; and a thermal cutoff (TCO) element having a first end electrically connected to the second lead on the dielectric barrier and a second end electrically connected to the second electrode;

wherein the first and second electrodes are formed of a material having a melting point greater than 1100

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degrees Celsius, and wherein the first and second electrodes are planar and are disposed in a parallel relationship with one another.

9. The TMOV device of claim 8, wherein the dielectric barrier prevents direct electrical connection between the second lead and the second electrode.

10. The TMOV device of claim 8, wherein the first and second electrodes are formed of a ferrous-based material.

11. The TMOV device of claim 10, wherein the first and second electrodes are formed of galvanized steel.

12. The TMOV device of claim 10, wherein the first and second electrodes are formed of tin-coated steel.

13. The TMOV device of claim 10, wherein the first and second electrodes are formed of cermet.

14. The TMOV device of claim 8, wherein the first and second electrodes have a thickness in a range of 0.2 to 0.6 millimeters.

15. The TMOV device of claim 8, further comprising a dielectric polymer coating covering the MOV chip, the first and second electrodes, the dielectric barrier, the TCO element, and portions of the first and second leads.

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